Proposed Functional Architecture and Associated Benefits Analysis of a Common Ground Control Station for Unmanned Aircraft Systems

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CDR Michael Supko

NAVAIR NPS Cohort #1
October 2010
# Capstone Team

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<thead>
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<td>Jim Nadeau</td>
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<th>Advisors</th>
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<td>Mr. Gregory Miller</td>
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<td>CAPT John Schmidt</td>
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Full report available at [www.dtic.mil](http://www.dtic.mil)
Report # NPS-SE-10-002
Problem Definition

The rapid growth in UASs has resulted in a lack of commonality across the DoD which has contributed to:

• Unique training for all systems
• Large manpower requirements for projected systems
• Unique hardware, software, and logistics support
ADM dated 11 February 2009

Result of GCS Review of Predator, Reaper and Sky Warrior UAS

Addressed to Secretary of the Army, Navy, & Air Force

Goal: Reduce life cycle cost in the development, operation, and sustainment of UASs

“The acquisition team has the opportunity to do something truly joint and powerful by adopting a common GCS architecture that is open and thus will allow for rapid addition of modular functionality”

Hon John Young
Former USD (AT&L)
Tailored Systems Engineering Process

- Acquisition Decision Memo
- STANAG
- UAS Roadmap
- GAO Reports

Information Gathering & Problem Definition
- Elements Influencing Commonality
- Areas Impacted by Commonality

Concept Development
- Needs Statement
- Requirements
- AoA and Gaps
- Initial Functional Architecture

Engineering Development
- Detailed Requirements
- Recommended Functional Architecture

Design Recommendations & Conclusions
- Common GCS Functional Architecture
- Process for Implementing Architecture
- Assessment of Benefits from Using Common GCS

Problem Scoping
- Stakeholder Feedback

Stakeholder Analysis
- AoA and Gap Analysis
- Requirements and Constraints

Initial Functional Analysis
Elements Influencing Commonality and Project Scope

- **Commonality vs. Interoperability**
- **Airframe Size and Groupings**
  - Limit scope to Groups 3 and above.
- **Air Vehicle Control versus Mission Specific Payload**
  - Explore commonality and interoperability for air vehicle control functions only.
- **Human-Machine Interface**
  - Examine common HMI for air vehicle control functions only.
- **Hardware and Software**
  - Limit to a functional level, therefore hardware and software allocation is not required.
- **Implementation through Retrofit or New Production**
  - Consider implementing the proposed functional architecture on new production assets only, retrofit will not be explored.
- **Department of Defense Multiservice Cooperation**
  - Concentrate on Department of Navy systems and requirements.
- **United States and Allied Cooperation**
  - Limit scope to U.S. only.
Areas Impacted by Commonality and Project Scope

- **Training**
  - Training is the primary focus for the benefits of the proposed common architecture.
- **Basing**
  - Potential benefits examined only when related to training as described in above section.
- **Manpower Requirements**
  - Potential benefits examined only when related to training as described in above section.
- **Personnel Assignments**
  - Potential benefits examined only when related to training as described in above section.
- **Reliability and Maintainability (R&M)**
  - Not examined further as part of this effort.
- **Other Logistical Areas**
  - Not examined further as part of this effort.
- **O&S and Development Cost**
  - Potential benefits examined only when related to training as described in above section.
- **Mission Capability**
  - Not examined further as part of this effort.
Navy Program of Record Comparisons

• Researched requirements documents for the following programs of record in DON:
  - BAMS, Fire Scout, STUAS

• Review of KPPs & lower-level req’ts:
  - Net Ready is only common KPP between these programs
  - Few KPPs related to GCS, majority are for air vehicle
  - No requirements for:
    » Interoperability with heterogeneous UASs
    » GCS commonality with heterogeneous UASs
    » Training commonality with other UASs
Any commonality being sought is between manned and unmanned system counterparts:

- **BAMS & P-8A**
- **Fire Scout & MH-60R/S**
Chairman JCS UAS Training Standards

CJCSI 3255.01 Joint Unmanned Aircraft Systems Training Standards

<table>
<thead>
<tr>
<th>UAS Group</th>
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<th>BUQ II</th>
<th>BUQ III</th>
<th>BUQ IV</th>
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Focus Area: Group 3 and above (BAMS, Fire Scout, STUAS)

- Mandated Minimum BUQ levels and JMQs required for each UAS Group
- Dated September 2009

BUQ = Basic UAS Qualification
KSA = Knowledge, Skills and Abilities
Proposed Requirements for a Common GCS

The Ground Control Station shall:

1. Enable Air Vehicle Operator (AVO) training commonality across multiple UAS platforms.
2. Utilize a common HMI for AVO functions.
3. Utilize directed vice controlled air vehicle operation.
4. Utilize separate HMI for payload and air vehicle control.
5. Utilize a common mission planning system.
6. Enable interoperability between multiple UASs.
7. Enable common communications and data link management between multiple UASs.
8. Utilize a common data format to enable communication between multiple manned and unmanned systems.
9. Utilize modular and scalable systems software and architecture.
10. Enable a common approach to simplify support and maintenance across multiple UAS platforms.
11. Enable a common approach to reduce the manpower requirements across multiple UAS platforms.
12. Enable a common approach to minimize UAS basing.
Design of the Proposed Common GCS Architecture

• Focused on a common HMI for the air vehicle control functions of Groups 3-5 UASs

• Based on:
  - The preceding 12 requirements
  - Documents from BAMS, Fire Scout and STUAS
  - NATO and US standards
  - Unmanned Systems Integrated Roadmap

• Functional architecture created with CORE (commercial model-based systems engineering tool) and communicated via hierarchical charts, flow diagrams and IDEF0 language
A-1: External Systems Diagram

C1
AOI
COI
TOI

C2
Command

C3
Air Traffic

C0
UAS

GCS

UAV

C4
Customer

C5
Environment

C6
Threat

Energy, Data

Weapon

Tasking & Weapon Auth

UAS Data

AV & Payload Control

Data Transfer

UAS & Payload Data

Weather, E3

Kinetic & Non-Kinetic Attack

Air Traffic Mgt

Air Traffic Data
A0: UAS Functions Diagram

Weather
E3
Data Transfer (from Customer)
Threat Attack (Kinetic, Non-Kinetic)

Data from COI
Energy from AOI-COI-TOI

Payload Control
Weapons Authority
Air Vehicle Control
Air Traffic Management

Data Transfer to Customer
Data for Air Traffic
UAS Data

A1: Perform GCS Functions

Tasking

Payload Control for GCS
GCS AV Control
Data Transfer from GCS

Data Transfer from UAV

A2: Perform Air Vehicle Functions

Energy from UAS Sensor
Data Transfer to COI
Weapons from UAV
Payload or Payload Data
A1: Perform GCS Functions

A1.1: Provide Human Interface

A1.2: Plan Mission

A1.3: Manage Mission

A1.4: Command and Control Air Vehicle

A1.5: Control Payload

A1.6: Process Payload Data

A1.7: Manage Comms & Disseminate Data

A1.8: Perform External Comms

Payload Control for GCS
GCS AV Control
Data Transfer to Customer
Data Transfer from GCS
Data for Air Traffic

Data for Mission Planning & Mgt
AV Status
Payload Data
Complete IDEF0 Diagrams

A-1: JUCCS External Node Context Diagram
Requirement 2: Common GCS HMI for AVO Functions

Requirement 3: Directed vice controlled air vehicle operations

Requirement 4: The AVO and payload operators shall have separate controls

(The common HMI and directed vice controlled operations are enabled by breaking out the interface function separately)

Requirement 7: Common communications and data links

Requirement 8: Common data format
Basic UAS Qualification (BUQ) Analysis Results

<table>
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<tr>
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<th>As-Is GCS Architecture</th>
<th>JUCCS Proposed Common GCS Architecture</th>
<th>Total KSAs per Architecture</th>
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<tr>
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<td>Common KSAs</td>
<td>Unique KSAs</td>
<td>Common KSAs</td>
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<td>TOTAL</td>
<td>59</td>
<td>154</td>
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A Common GCS Architecture reduces the number of platform-unique KSAs to only seven. These seven KSAs all deal with functions that are unique to the specific UAS (pre-flight, post-flight, emergencies).
Current Training Concepts
Utilize Multiple Locations

NAS Whidbey Island, WA
MCS/MST

MCAS 29 Palms, CA
VMU-1, VMU-3
Shadow (2 IMS)

MCAS Cherry Point, NC
VMU-2
Shadow (1 IMS)

NORFOLK
MQ-8B (FY15)
MQ-8B Maint Trainer (FY15)

MAYPORT
MQ-8B TOFT (FY14)
MQ-8B Maint Trainer (FY14)

MCAS 29 Palms, CA
VMU-1, VMU-3
Shadow (2 IMS)

Fort Huachuca, AZ
UAV Systems Training Center
Shadow/Hunter
22 networked simulators
Electronic Classrooms

GUAM
MQ-8B TOFT (FY18)

NAS Whidbey Island, WA
MCS/MST

MCS/MST
POR – 5 sites (2 CONUS, 3 OCONUS)
BCA Results: shift to 5 MCS at 2 CONUS locations, likely NAS JAX and NAS WI
Maintenance Location TBD

BAMS = Blue
Fire Scout = Red
Shadow = Gray
Possible AVO Training Flow for the Proposed Common Architecture with a Common Schoolhouse

- NEW ACCESSION
- BUQ I - IV Qualification Course of Instruction
- BUQ I - IV Refresher Training
- 206/213 BUQ I-IV KSAs
- BAMS Operational Units*
- Fire Scout Operational Units*
- STUAS Operational Units*

* Remaining 7 KSAs taught at Squadron

Highlights
- 206/213 KSAs taught across all Group 3-5 UASs
- 7 KSAs pushed to operational units for instruction
- Two Courses of Instruction
  - New Accessions
  - Previous Operators (Refresher Training)
- Common location proposed for Core Training
Recommendations

• Modify NAVAIR acquisition process for UAS programs
  - Create common GCS program office that is separate from UAV program offices
  - Common GCS program office would:
    » Coordinate with all UAS program offices
    » Maintain and update the architecture and software
    » Utilize a common HMI module
    » Hardware agnostic (minimum req’ts and ICDs)
    » Maintain single command set for interoperability between heterogeneous UAVs
• Mandate the requirement for a common GCS
Questions?

Full report available at www.dtic.mil
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